DIAGNOSIS OF A STRONG CYCLOGENESIS DURING IOP18 OF HyMeX-SOP1

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During the HyMeX-SOP1 (a field campaign dedicated to heavy precipitation and flash flooding) several high-impact weather events occurred and were documented throughout large amounts of ordinary and extraordinary observations. The availability of detailed observations offers a good opportunity to further explore these events and to assess the skill of numerical weather prediction models. In most of the six Intensive Observation Periods (IOPs) that affected the Spanish regions a cyclone was involved. In particular, during IOP 18 an small-scale intense cyclogenesis occurred on 31 October 2012. The cyclone tracked along NW Mediterranean. It initially intensified near Catalonia, where heavy rain was recorded, and then travelled towards the north of Minorca island, which was affected by strong winds. Finally, the cyclone moved towards the Gulf of Genoa, with heavy precipitation again in some Italian regions.

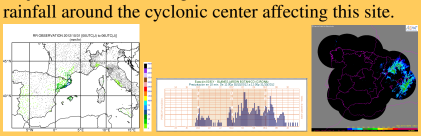
The present study focuses on the diagnosis of the cyclogenesis event of IOP 18. The diagnosis is performed by means of two numerical models, the ECMWF model and the Arome-WMED reanalysis. The cyclone has been detected and characterised from mean sea level pressure analyses and its vertical structure has also been described by using phase space diagrams. The role of a cut-off low from Iberian Peninsula, the release of latent heat during the precipitation period and the warm and wet air advection in the deepening of the cyclone are analysed as potential cyclogenetic factors. Heavy rain and strong wind have occurred in connection with this cyclone evolution.

IOP 18 EVENT. OBSERVATIONS

During the early hours of October 31, 2012 a strong cyclogenesis affected Western Mediterranean, which was accompanied by heavy rainfall in some hydro-meteorological sites of Spanish territory (Catalonia and Balearic Islands) and subsequently Italian area (Liguria-Tyrrhenian), when the cyclone moved towards the NE of Italy, and by strong winds, at least in the Balearics and Sardinia.

00 - 06 UTC

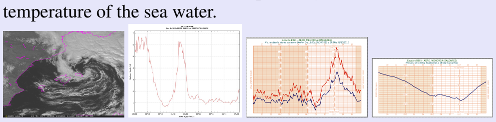
Intense rain had recorded in the North-West Mediterranean site, with 112 $mm/12\ h$ in Catalonia (maximum intensity from 02 UTC to 07 UTC) and 60 $mm/12\ h$ in Majorca. The radar image shows the curved structure of rainfall around the cyclonic center affecting this site.



Rainfall in 6h, time distribution of precipitation in Blanes (Catalonia), AEMET national composite RADAR 31/10 06:20 UTC

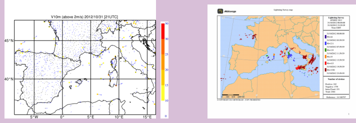
09 - 15 UTC

The cyclone intensifies and in accordance with its movement, a very active rainy and windy area progresses eastward, concerning Minorca about 12:30 UTC, with 39/63 kt westerly wind and mean sea level pressure (MSLP) lower than 986 hPa. Exceeding 40 kt winds were also recorded at buoys located at Goulf of Lyon and Cote d'Azur, with waves of more than 4 and 6 m respectively, and with a sudden drop in temperature of the sea water.



VIS satellite images at 12:30 UTC, Wave height in Marseille, Time distribution of wind and station-level pressure recorded in Airport of Minorca

18 - 21 UTC



Observed wind at 10m 21 UTC   Zeus ligthning data 31/10/2012

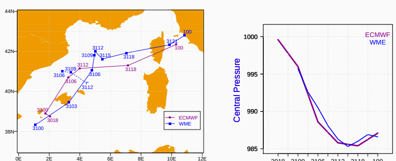
21 UTC strong winds affected Sardinia. Rainfall affected North of Italy: South-westerly and southerly moist advection induced orographic precipitation over Lazio and Liguria regions, respectively, with isolated peaks of 120 $mm/24\ h$. Over NE of Italy, convective squall lines developed on 31 October into the Scirocco flow over Northern Adriatic Sea, and over the mainland.

ANALYSIS

The diagnosis is performed mainly by means of 3 hourly Arome-WMED reanalysis (hereafter WME), a version of the operational convection-permitting AROME model, covering the western Mediterranean basin, with 2.5 km of resolution, and by means of 6 hourly analyses from ECMWF T1279 model, (hereafter ECM), a convection-parameterized model of 16 km of resolution.

Cyclone tracks

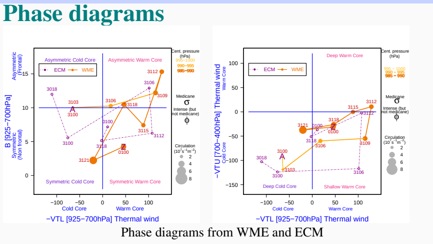
WME detects two cyclonic centres, the principal cyclone (PC), first detected at 00UTC south of Balearic Islands which intensifies and moved towards the north and north-east, and a secondary centre (SC) which lasts from 06 to 12, when becomes an open low and merges with the PC. ECM detects only the PC, because of small size of SC.



Analysed PC (solid) and SC (dashed) tracks and pressure value from WME and from ECM

During the intensifying phase, the pressure drops sharply in the center of the PC at a rate of 0,77hPa/h according to ECM and 0,75Pa/h according to WME along 12 h, very close to, but not enough, to be 0,8hPa/h rate and not during the 24 h required, to be considered explosive cyclogenesis.

Phase diagrams



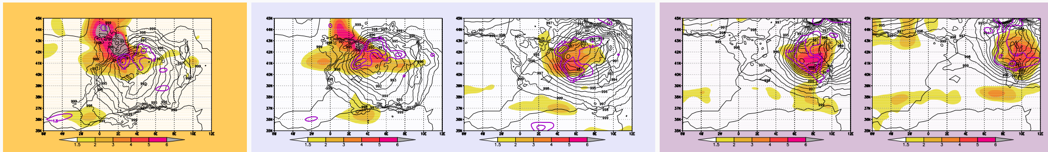
Phase diagrams from WME and ECM

The PC evolves from an asymmetric deep cold core to a shallow warm core, becoming a deep warm core at 12 UTC 31th. The extratropical cyclone undergoes a warm seclusion. The ECM analysis gives a similar evolution, although less detailed. The SC is a shallow warm core cyclone, associated with the release of latent heat (not shown). The heating increase the mid-level warm anomaly which become deeper in the vertical.

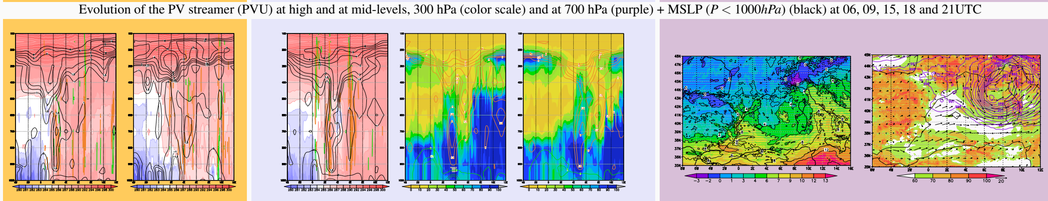
Upper level anomalies

Regarding the upper levels, on the 30th October at 18UTC a cut-off approximates the Catalan coast from the Iberian Peninsula. It is reflected in a PV streamer in the PV-charts ($1PVU = 10^{-6}m^2Ks^{-1}kg^{-1}$) from WME. At 06UTC on 31th the cut-off reaches the coast, enters the Mediterranean and travels south-eastwards, decreasing its extents and intensity. At 18UTC it reactivates and crosses Corsica towards North-East, reaching Ligurian sea 1st of November at 00UTC.

06 UTC   09 - 15 UTC   18 - 21 UTC



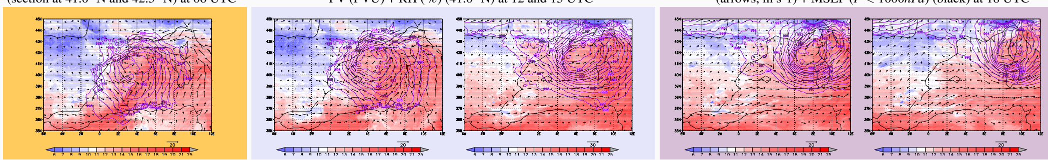
Evolution of the PV streamer (PVU) at high and at mid-levels, 300 hPa (color scale) and at 700 hPa (purple) + MSLP ($P < 1000hPa$) (black) at 06, 09, 15, 18 and 21UTC



Vertical profile of PV (PVU) + TPW (K) (section at 41.0°N and 42.5°N) at 06 UTC

Vertical profile of PV (PVU) + TPW (K) at 09 UTC, PV (PVU) + RH (%) (41.0°N) at 12 and 15 UTC

T at 800 hPa (C) and RH (%) at 925 hPa + 10 m wind (arrows, m s-1) + MSLP ($P < 1000hPa$) (black) at 18 UTC



Evolution of the 10 m wind (arrows, m s-1) and TPW (C) at 925 hPa (color scale) + MSLP ($P < 1000hPa$) (black) at 06, 09, 15, 18 and 21UTC

At 700 hPa at 06UTC two PV positive anomalies are located, one over the area of precipitation and another over the are a of warm advection. The first one is linked to the formation of one secondary cyclone (SC) and the second one with the deepening the principal cyclone (PC). In fact, from the vertical profile of PV and pseudo-adiabatic potential temperature (TPW), made along the parallel 41N, a column of rising warm air 500 hPa thick, the warm conveyor belt (WCB), is located at 4-5E and moves eastwards to 8-10E.

From the vertical profile of relative humidity (RH), at 12UTC a tongue of dry air, ($RH < 30\%$), and a PV streamer ($PV > 3UPV$ at 500 hPa) at 4-5°E, is linked to a dry air intrusion (DAI) until mid-level, entering the Mediterranean by the south and west of the cyclone and descending to 700 hPa and also moving eastward. At 15UTC the upper level perturbation is reactivated, associated with the dry air intrusion and during the following hours crosses Corsica towards North-East, reaching Ligurian sea 1st of November at 00 UTC. At 18UTC an isolated warm core is identified at mid-levels.

SUMMARY

During the 31th October 2012 a strong cyclogenesis with associated heavy rain events and strong winds affected Western Mediterranean, from Catalonia to Liguria. The cyclone evolution shows different stages, in which different cyclogenetic factors are involved.

- A small-scale cyclone is formed off the Spanish coast, when an upper-level cut-off reaches the east of Iberian peninsula and warm and wet air is advected from the south. The cyclone intensifies quickly during the first 12 hours, moving northward. The release of latent heat by intense rain induces the formation of a very small secondary cyclone, responsible for unusual extraordinary westerly wind and sudden pressure drop. The baroclinic and the diabatic contributions are reflected in PV streamers at high and mid levels respectively.
- At 15 UTC central pressure begins to increase slightly and the cyclone turns east. The warm conveyor belt also moves eastward. A dry air intrusion enters the Mediterranean by the south and west of the cyclone and reactivates the upper level perturbation. The cyclone crosses the island of Corsica and moves towards NE of Italy, where convective heavy precipitation is recorded.

The phase diagrams show that the intensifying phase the principal cyclone evolves from an asymmetric deep cold core to a shallow warm core, becoming a deep warm core at 12 UTC. Finally the extratropical cyclone undergoes a shallow warm core and the phase diagrams confirm that the cyclone developed into a warm-seclusion.

WME has been very useful to diagnose this event, because its spatial and temporal resolution allows to describe small structures and to track small-scale cyclones, even the SC. ECM describes fairly well the evolution of baroclinic cyclone, but with less detail.

REFERENCES

Campins, J et al., Int. J. of Clim., 2006
Davis, C. A. and Emanuel, K. A.,Mon. Weat. Rew., 1991
Drobinski, P. et al., BAM, 2014
Ducrocq, V. et al., BAM, 2014
Flaounas, E. et al, Clim Dyn, 2015
Fourrié, N. and Mathieu, N., REANALYSIS AROME WMED V1, 2014
Hoskins, B. J. et al., QJRMS, 1985
Jansà, A. et al., Met App, 2001
Jansà, A. et al., Tehys, 2014
Mariani, S. et al., NHESS, 2014
Maue, R.N., Electronic Theses, 2010
Picornell, M.A. et al., NHESS, 2014

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